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(56) Documents Cited
Voice/data integrated transmission on a time division CSMA/ CD network, Hughes/Jiang/Smith, cont... Proceedings of the 1987 Summer Computer Simulation Conferenc e p.325-30, 1987 "Simulation studies of the movable-slot TDM protocol", Hon/ Lee, Proceedings of the 1987 cont ..... Symposium on the Simulation of Computer Networks, P.239-46, 1987 "Performance of integrated services (voice/data) CSMA/CD net works", Chlamtac/Eisinger, cont ..... Performance Evaluation Review vol 13 no 2, spec. issue., p. 87-93, Aug 1985. "Voice and data on a CATV network", Maxemchuk/Metravali, IEE

(56) continued overleaf

(54) Combined CSMA/CD and TDM communications protocol for use in a home and building electrical management system

(57) A packet communications network 10, 12 connects two or more control devices 14, 16, 18 and 20 in a home electrical management system. The digital data exchange protocol comprises the use of Carrier Sense Multiple Access/Collision Detection protocol (CSMA/CD as shown in figure 2), having an additional frame (figure 3) in the packet to initiate a TDM communication period during which the status of each device can be transmitted to each other device connected to the network.

The protocol allows the flexibility of CSMA/CD to be used while using the speed of the TDM frame to gain status information.

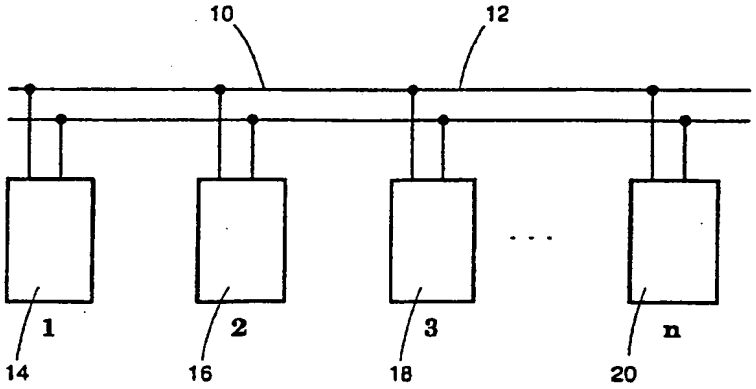

FIGURE 1

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(56) cont

E Journal on Selected Areas in cont .... Communications vol. SAC-3, no 2, p.300-11, March 1985 "Some characteristics of movable slot TDM", Maxemchuk, 8th Conference on Local Computer cont ..... Networks, p.62-9, 1983 "On a hybrid TDMA/CSMA LAN accessing scheme serving users with a variable traffic character cont.. istics and minimizing an operating delay metric", Dimitriadis/Polyzos/Alexandridis/Oucheriah cont IEEE International Conference on Communications, 1983 A variation on CSMA/CD that yields movable TDM slots in inte grated voice/data local networks", cont Maxemchuk, Bell System Technical Journal vol 61, no 7 pt 1 p.1527-50, Sept 1982

(58) Field of Search

UK CL (Edition N) **H4K KOF , H4M ME MTX1 MX , H4P PPND**

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Online : WPI, INSPEC

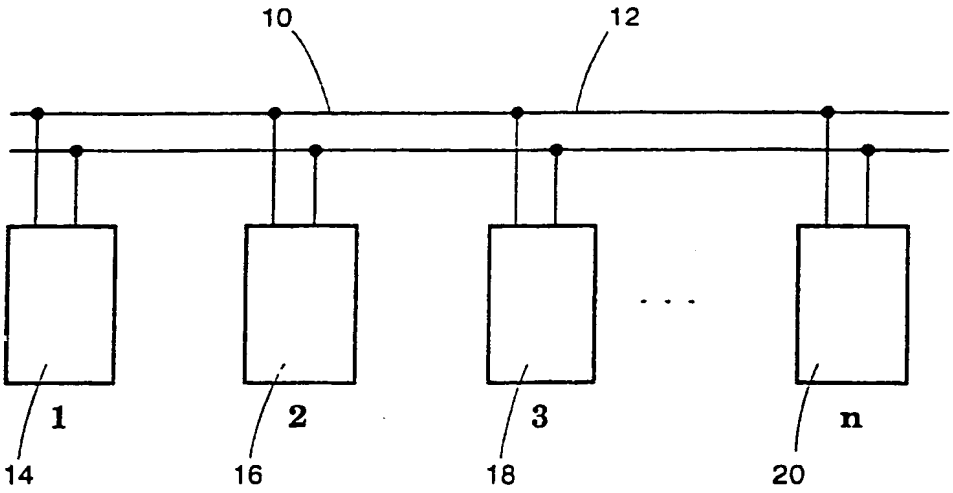


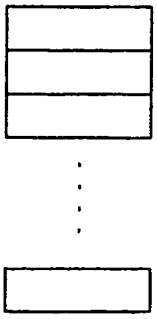
FIGURE 1

HEADER	CONTROL	DATA	CHECKSUM	DUMMY	ACK

FIGURE 2

HEADER	CONTROL	DATA	CHECKSUM	DUMMY	ACK	DUMMY

FIGURE 3



data from device with address 0
data from device with address 1
data from device with address 2

data from device with address 225

data can be of any format, as defined by control information in the header of the initiating frame

FIGURE 4

HOME AND BUILDING ELECTRICAL CONTROL PROTOCOL

This invention relates to home and building electrical management systems and in particular to a communications protocol suitable for use in such systems.

BACKGROUND TO THE INVENTION

A typical electrical control system for home and building installation comprises a quantity of devices designed to control switches, sockets; electrical loads of various types (e.g lighting, heating, cooling and various motorised devices), and protective devices such as miniature circuit breakers, residual current breakers, fuses etc. A control system in such an installation comprises one or more, low power consumption transceiver devices associated with one or more of the abovementioned electrical elements, the transceivers typically being connected in parallel via a communications medium.

For the sake of simplicity and cost it is typical for the communication medium to comprise a two-wire power and datagram (signal) means. The two-wire means may be provided with shielded or unshielded twisted pair. Various topologies such as bus, star, ring, mesh and/or a mixture of the above topologies can be used with this medium.

Each device in the network comprises a transceiver for receiving and transmitting data signals, a computer device for receiving data and sending data of its own volition dependent on programs stored therein and storage means to maintain various data (e.g. the status of other devices in the network), and control circuit means for controlling electrical apparatus (e.g. lights, switches, power loads) associated therewith.

Each device in the network is adapted and arranged to exchange data signals via the two-wire medium.

By linking the various devices it is possible to control and manage the various apparatus associated with each device each of which are controlled independent of the other.

The exchange of information between the devices is an important element in the control of devices on the network and exchange of information in digital form is typical. Digital signals can be designed to minimise information exchange errors which is important in safety critical environments. However, the communications medium has an inherent upper bandwidth for the quantity of digital information which it can carry at any one time. Therefore, there are a number of digital transmission techniques which can be used to best use the available bandwidth of the medium amongst the numerous and various types of devices distributed over the network. The ability of the communications medium to convey digital information to all the devices may also be restricted by its total length since digital signal transmission time from the devices most distant from each other may exceed an allowable period within which digital signals will not overlap in time.

One technique known as Time Division Multiplexing (TDM) allows each device to take a turn (in a round robin), each one periodically obtaining the entire data exchange bandwidth for a predetermined period of time. In using this technique transmission time is uniquely segmented amongst the devices and each segment of time carries data transmitted from one and only one of the devices within the network. During this time all of the devices on the network can read data provided by the device transmitting (broadcast data). A TDM technique requires the allocation of a unique time slot to each of the existing and/or future devices, and each time slot beginning and end is synchronised to a master clock located in the network.

All devices contribute a predetermined amount of digital data, one after the other, until every device has sent all its data. This procedure is advantageous and particularly

efficient where frequent updating of data is required either by a central controller or each device itself. In a network where all devices are required to know the operating mode or condition of other devices on the network TDM offers a means for orderly exchange of information. However, this arrangement is very inflexible and may limit the amount, and sometimes the complexity, of the digital data being communicated from each device.

One limitation of the TDM technique is that each time slot must be interpreted unambiguously by all communicating devices. A central synchronising clock may initiate each data exchange transmission period but delayed digital data resulting from signal propagation delays along the network will result in the loss or corruption of data. The receiving device will not easily determine which bits of data are from which sets of data thus no data can be safely accepted by the receiver. For this reason, TDM is not ideal for long or lengthening network distances.

A further digital data communication technique used in such networks is known as Carrier Sense, Multiple Access, with Collision Detection (CSMA/CD) and is most commonly used wherever data must be communicated between one of many devices widely distributed over a large network. A further enhancement of the CSMA/CD scheme is to include some form of Collision Avoidance (CA) so that the inevitable collision of digital data information packets and the frequency thereof, may be reduced or recovered if data is lost as a result of collisions.

CSMA/CD - CA does not require any central coordination, so it is well suited to a home building electrical control system requiring relatively high digital data exchange rates for communicating information between widely distributed intelligent devices, such as those described above.

However, in a bandwidth limited network using, for example, the type of two-wire medium described above, CSMA/CD is not

necessarily optimumly configured for the quick gathering of information from a large number of devices. Since communication between devices must be established one at a time and during any one such communication period, only one unit may transmit at any one time. CSMA/CD is therefore an inefficient technique for the exchange of status information between many devices.

BRIEF DESCRIPTION OF THE INVENTION

In a broad aspect of the invention a digital data exchange protocol for use on a packet switched communications network for connecting between two or more control devices comprises the use of a Carrier Sense, Multiple Access/ Collision Detection packet switched protocol, having an additional frame adapted to initiate a time division multiplex communication period during which the status of each of said devices can be transmitted to each other device connected to said network.

A digital data exchange protocol wherein the Carrier Sense, Multiple Access/ Collision Detection protocol also uses Collision Avoidance.

A digital data exchange protocol wherein during said time division multiplex communication period, time slots for each device are synchronised by a single clock referred to by the network.

A digital data exchange protocol wherein said time division multiplex communication period is greater than the propagation delay between devices which are physically furthest apart as measured through the network.

A specific embodiment of the invention will now be described in some further detail with reference to and as illustrated in the accompanying figures. This embodiment is illustrative, but not restrictive of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Fig. 1 is a basic layout of a plurality of devices arranged in a network interconnected by a pair of wires;

Fig. 2 is a timing diagram of a CSMA/CD - CA digital data frame;

Fig. 3 is a TDM initiating frame of an CSMA/CD - CA frame; and

Fig. 4 is a schematic of a TDM data exchange protocol in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

A large variety of information, control and management systems utilising packet switched communication networks with two-wire power and communication mediums are used for an equally large variety of applications. In particular, packet switched networks are being used more often in the residential, commercial building and industrial buildings construction industry to support building control management systems.

Pairs of conductors are typically easily laid and routed in new and existing buildings and simple tap-in line connections are connectable at any point along the pair of conductors, as depicted pictorially in Fig. 1. Wires 10 and 12 provide a medium for the communication of power and signals to the devices 14, 16, 18 and 20 which are distributed as required along the length of the wires 10 and 12.

In this embodiment the digital data exchange protocol may preferably be of the CSMA/CD - CA type, of which Fig. 2 depicts a typical frame where in this example control = O. However, when required, a special frame, as depicted in Fig. 3 where control is not equal to O, can be sent by any device within the network to initiate a TDM communication period.

During the TDM period, all participating devices may preferably be synchronised by that special frame, and/or as well as by a synchronising clock, which is present on the communications medium at all times. The synchronising clock provides a timing reference only and therefore can be generated by an "non-intelligent" clock device located anywhere on the network.

It is preferable for the design of a communication protocol using CSMA/CD and/or CA which uses a TDM initiating frame, to have a predetermined maximum bandwidth and maximum physical length of the two-wire communication medium. Predetermining these two characteristics reduces the probability and/or incidence of timing errors that may occur if either is exceeded.

Further, it is preferable for all the connected devices to be adapted to maintain TDM data sending synchronisation with the received frame which initiates the TDM digital data exchange period.

Furthermore, it is preferable that the initiating frame of the device requesting a TDM protocol period contains sufficient information to allow participating devices to contribute the appropriate information within that TDM frame period.

Typically in this embodiment the TDM frame period is used by all the devices on the network for collecting information about all other devices currently operational on the network, as depicted pictorially in Fig. 4. The type of information that may be provided comprises the status of one or all of the devices in the network, or alternatively groups of devices in the network, or even the existence of a newly added device to the network. A list of all active devices may be maintained either centrally or distributed amongst all devices and this simplifies and assists in the identification

of current and potential communication and set up problems between devices.

Using a specialised TDM frame period for quickly exchanging information within a predominantly CDMA/CD - CA protocol ensures that important information is quickly and more importantly efficiently exchanged between each device. A conventional CSMA/CD - CA communication protocol makes multiple (not necessarily successful) communication attempts when requiring the exchange of similar information amongst the devices on the network and takes longer and unnecessarily uses sometimes scarce bandwidth.

Since each frame of the CSMA/CD - CA protocol is confirmed as being received correctly upon its receipt, the status of the apparatus or load connected to the device will have changed as required. Consequently information collected during any simultaneously initiated TDM frame will also confirm a change of operational status of the initiating or sending device.

This preferable use of a TDM frame period amongst a CSMA/CD - CA protocol ensures a reduction in the quantity of re-transmissions which would typically be required in a CSMA/CD - CA protocol exchange of information. This has particular advantages at the typically low communication rates of two-wire communication mediums used in building management networks.

The invention has been described using a specific packet switching network making use of both CSMA/CD - CA and TDM communication protocols in order to achieve efficient usage of the available bandwidth.

However, it will be appreciated by those skilled in the art that the invention is not restricted in its use to the particular application described and neither is the present invention restricted in its preferred embodiment with regards to the particular components and/or configuration of protocol elements described herein. It will be appreciated that

various modifications can be made without departing from the principles of the invention, therefore, the invention should be understood to include all such modifications within its scope.

Claims:

1. A digital data exchange protocol for use on a packet switched communications network for connecting between two or more control devices comprises the use of a Carrier Sense, Multiple Access/ Collision Detection packet switched protocol, having an additional frame adapted to initiate a time division multiplex communication period during which the status of each of said devices can be transmitted to each other device connected to said network.

2. A digital data exchange protocol in accordance with claim 1 wherein the Carrier Sense, Multiple Access/ Collision Detection protocol also uses Collision Avoidance.

3. A digital data exchange protocol in accordance with any preceding claim wherein during said time division multiplex communication period, time slots for each device are synchronised by a single clock referred to by the network.

4. A digital data exchange protocol in accordance with claim 1 wherein said time division multiplex communication period is greater than the propagation delay between devices which are physically furthest apart as measured through the network.

5. A digital data exchange protocol as hereinbefore described with reference to the accompanying drawings.

The Patent Office

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Application No: GB 9505620.6 **Examiner:** Simon Rees
Claims searched: 1-5 **Date of search:** 18 July 1995

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.N): H4M (ME, MTX, MX), H4P (PPND), H4K (KOF)

Int Cl (Ed.6): H04L (12/413), H04J (15/00), H04M (11/00)

Other: ONLINE: WPI, INSPEC

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	"Voice/data integrated transmission on a time division CSMA/CD network", Hughes/Jiang/Smith, Proceedings of the 1987 Summer Computer Simulation Conference p.325-30, 1987	1
X	"Simulation studies of the movable-slot TDM protocol", Hon/Lee, Proceedings of the 1987 Symposium on the Simulation of Computer Networks, p.239-46, 1987	1
X	"Performance of integrated services (voice/data) CSMA/CD networks", Chlamtac/Eisinger, Performance Evaluation Review vol.13, no.2, spec. issue, p.87-93, Aug 1985.	1
X	"Voice and data on a CATV network", Maxemchuk/Netravali, IEEE Journal on Selected Areas in Communications vol.SAC-3, no.2, p.300-11, March 1985.	1
X	"Some characteristics of movable slot TDM", Maxemchuk, 8th Conference on Local Computer Networks, p.62-9, 1983.	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

The Patent Office

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X	"A variation on CSMA/CD that yields movable TDM slots in integrated voice/data local networks", Maxemchuk, Bell System Technical Journal vol.61, no.7, pt.1 p.1527-50, Sept. 1982.	1

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